CLAIMS

1. A touch sensitive apparatus, comprising:

a touch plate;

a plurality of sensors coupled to the touch plate, each of the sensors configured to sense bending waves in the touch plate;

an excitation transducer coupled to the touch plate and configured to induce bending waves in the touch plate;

a plurality of active buffer circuits, each of the active buffer circuits respectively coupled to one of the sensors; and

a controller coupled to the sensors via the active buffer circuits and to the excitation transducer via a non-actively buffered connection, the controller configured to compute information related to a touch on the touch plate responsive to sense signals received by the sensors.

2. The apparatus of claim 1, wherein the information related to the touch comprises touch location.

3. The apparatus of claim 1, wherein the information related to the touch comprises information concerning detection of a lift-off of the touch.

4. The apparatus of claim 1, wherein:

the touch plate is substantially rectangular;

the plurality of sensors comprises four sensors each positioned at a respective corner of the touch plate; and

the excitation transducer is positioned proximate a peripheral edge of the touch plate.

5. The apparatus of claim 1, wherein the plurality of sensors comprises piezoelectric sensors.

6. The apparatus of claim 5, wherein the excitation transducer comprises a piezoelectric transducer.

7. The apparatus of claim 1, wherein each of the active buffer circuits comprises a field effect transistor.

8. The apparatus of claim 1, wherein the plurality of sensors, the plurality of active buffer circuits, and the excitation transducer are respectively disposed on the touch plate.

9. The apparatus of claim 1, wherein the excitation transducer is configured to induce bending waves in the touch plate and to sense bending waves in the touch plate.

10. The apparatus of claim 1, wherein each of the sensors is configured to provide a differential sense signal to a balanced input of one of the active buffer circuits, and each of the active buffer circuits is coupled to a balanced input of the controller.

11. The apparatus of claim 1, wherein:

the sensors produce bending wave signals responsive to the induced bending waves; and

the controller computes relative dimensions of the touch plate using the bending wave signals.

12. The apparatus of claim 1, wherein:

the sensors produce bending wave signals responsive to the induced bending waves; and

the controller computes absolute dimensions of the touch plate using the bending wave signals.

13. The apparatus of claim 1, wherein:

the sensors produce bending wave signals responsive to the induced bending waves;

the controller computes dimensions of the touch plate using the bending wave signals; and

the controller computes a phase response of each of the sensors using the computed touch plate dimensions, a dispersion relation, and a measured phase response.

14. The apparatus of claim 1, wherein the excitation transducer induces bending waves in the touch plate in response to a non-audible tone signal.

15. The apparatus of claim 1, wherein the controller comprises an analog-to-digital converter (ADC) having a sampling frequency, the controller generating a tone signal having a frequency substantially equal to that of the sampling frequency of the ADC and communicating the generated tone signal to the excitation transducer.

16. The apparatus of claim 1, wherein the excitation transducer induces bending waves in the touch plate in response to a non-audible multiple tone signal.

17. The apparatus of claim 16, wherein the multiple tone signal comprises tones having frequencies that are spatially non-periodic.

18. The apparatus of claim 1, wherein the excitation transducer induces a non-audible broadband noise stimulus in the touch plate.

19. The apparatus of claim 1, wherein the excitation transducer induces bending waves in the touch plate in response to receiving a swept tone signal from the controller, the sensors producing bending wave signals responsive to the induced bending waves.

20. The apparatus of claim 19, wherein the controller comprises a demodulator that demodulates the bending wave signals synchronously with respect to the swept tone signal.

21. The apparatus of claim 1, wherein:

the controller comprises an analog-to-digital converter (ADC) having a sampling frequency, f_s; and

the excitation transducer induces bending waves in the touch plate having frequencies greater than $f_s/2$.

22. The apparatus of claim 21, wherein:

the sensors produce bending wave signals responsive to the induced bending waves having frequencies greater than $f_s/2$; and

the ADC registers the bending wave signals as aliased bending wave signals having frequencies lower than $f_s/2$.

23. The apparatus of claim 1, wherein:

the controller comprises an analog-to-digital converter (ADC) having a sampling frequency, f_s; and

the excitation transducer induces bending waves in the touch plate having a frequency substantially equal to f_s.

24. The apparatus of claim 23, wherein:

the sensors produce bending wave signals responsive to the induced bending waves; and

the ADC registers the bending wave signals as aliased bending wave signals having a dc offset determined by an amplitude and a phase of the induced bending waves.

25. The apparatus of claim 1, wherein:

the excitation sensor is configured to induce bending waves in the touch plate and to sense bending waves in the touch plate; and

the controller further comprises wake-up circuitry coupled to the excitation sensor, the wake-up circuitry configured to generate a wake-up signal in response to the excitation sensor sensing a touch to the touch plate and to communicate the wake-up signal to the controller.

26. The apparatus of claim 25, wherein at least the active buffer circuits transition from a sleep mode to an operating mode responsive to the controller receiving the wake-up signal.

27. The apparatus of claim 1, further comprising a display coupled to the touch sensitive apparatus.

28. The apparatus of claim 1, further comprising:

a display coupled to the touch sensitive apparatus; and

a host processor coupled to the display and the touch sensitive apparatus.

29. A method for use with a touch sensitive device comprising a touch plate to which an excitation transducer and a plurality of sensors are respectively coupled, the method comprising:

applying an excitation signal generated by the excitation transducer to the touch plate and sensing the excitation signal by each of the sensors;

determining a transfer function of an input at the excitation transducer to an output at each of the sensors;

determining, for each of the sensors, a dispersion corrected impulse response using the transfer function; and

performing a calibration of the touch sensitive device using the respective dispersion corrected impulse responses.

30. The method of claim 29, wherein performing the calibration of the touch sensitive device comprises performing a calibration of the touch plate.

31. The method of claim 29, wherein performing the calibration of the touch sensitive device comprises determining dimensions of the touch plate.

32. The method of claim 29, wherein performing the calibration of the touch sensitive device comprises determining absolute dimensions of the touch plate.

33. The method of claim 29, wherein performing the calibration of the touch sensitive device comprises performing a calibration of each of the sensors.

34. The method of claim 29, wherein performing the calibration of the touch sensitive device comprises determining a phase response of each of the sensors.

35. The method of claim 29, wherein performing the calibration of the touch sensitive device comprises determining an amplitude response of each of the sensors.

36. The method of claim 29, wherein performing the calibration of the touch sensitive device comprises determining a phase response of each of the sensors, the method further comprising correcting for phase response differences between the sensors when performing touch location detection.

37. The method of claim 29, wherein performing the calibration of the touch sensitive device comprises determining an amplitude response of each of the sensors, the method further comprising correcting for amplitude response differences between the sensors when performing touch location detection.

38. The method of claim 29, wherein performing the calibration of the touch sensitive device comprises determining a dispersion relation for the touch plate.

39. The method of claim 29, further comprising repeatedly performing the calibration of the touch sensitive device and tracking changes in touch sensitive device calibration over time.

40. A method for use with a touch sensitive device comprising a touch plate to which an excitation transducer and a plurality of sensors are respectively coupled, the method comprising:

applying an excitation signal generated by the excitation transducer to the touch plate and sensing the excitation signal by each of the sensors;

determining a transfer function of an input at the excitation transducer to an output at each of the sensors;

measuring a phase component of a frequency response associated with the excitation signal sensed by each of the sensors; and

performing a calibration of the touch plate using the measured phase components.

41. The method of claim 40, wherein measuring the phase component of the frequency response further comprises mechanically or algorithmically enhancing detection of a first arrival of energy of the excitation signal by each of the sensors.

42. The method of claim 40, wherein performing the calibration of the touch plate comprises determining dimensions of the touch plate.

43. The method of claim 40, wherein performing the calibration of the touch plate comprises determining absolute dimensions of the touch plate.

44. The method of claim 40, wherein performing the calibration of the touch plate comprises:

calculating a phase ratio of total phase response to measured phase component for each of the sensors; and

calculating an aspect ratio of the touch plate using the phase ratio.

45. The method of claim 40, wherein performing the calibration of the touch plate comprises:

calculating a total phase response of first arrival energy for each of the sensors;

differentiating phase of the total phase response with respect to frequency;

characterizing a phase velocity as a function of frequency; and

determining a dispersion relation of the touch plate using the phase velocity characterization.

46. A method for use with a touch sensitive device comprising a touch plate to which an excitation transducer and a plurality of sensors are respectively coupled, the method comprising:

applying an excitation signal generated by the excitation transducer to the touch plate and sensing the excitation signal by each of the sensors;

determining a transfer function of an input at the excitation transducer to an output at each of the sensors;

calculating, in the time domain, an impulse response for each of the sensors using the transfer function;

measuring time of first energy arrival to each of the sensors;

calculating a distance from the excitation transducer to each of the sensors using the measured times of first energy arrival; and

calculating dimensions of the touch plate using the calculated transducer-to-sensor distances.

47. The method of claim 46, further comprising:

filtering the impulse response into one or more frequency bands; and

averaging the calculated distances for each of the frequency bands;

wherein calculating the touch plate dimensions comprises calculating dimensions of the touch plate using the averaged transducer-to-sensor distances.

48. The method of claim 46, wherein calculating the touch plate dimensions comprises calculating absolute dimensions of the touch plate.

49. A touch sensitive device, comprising

means for applying an excitation signal to a touch plate;

means for sensing the excitation signal at each of four corners of the touch plate;

means for determining a transfer function of an input at the excitation signal applying means to an output at each of the sensing means;

means for determining a dispersion corrected impulse response using the transfer function for each of the sensing means; and

means for performing a calibration of the touch sensitive device using the respective dispersion corrected impulse responses.

50. The device of claim 49, wherein the performing means comprises means for determining dimensions of the touch plate.

51. The device of claim 49, wherein the performing means comprises means for determining a phase response of each of the sensing means.

52. The device of claim 49, wherein the performing means comprises means for determining an amplitude response of each of the sensing means.

53. A touch sensitive device, comprising:

means for applying an excitation signal to a touch plate;

means for sensing the excitation signal at each of four corners of the touch plate;

means for determining a transfer function of an input at the excitation signal applying means to an output at each of the sensing means;

means for measuring a phase component of a frequency response associated with the excitation signal sensed by each of the sensing means; and

means for performing a calibration of the touch plate using the measured phase components.

54. A touch sensitive device, comprising:

means for applying an excitation signal to a touch plate;

means for sensing the excitation signal at each of four corners of the touch plate;

means for determining a transfer function of an input at the excitation signal applying means to an output at each of the sensing means;

means for calculating, in the time domain, an impulse response for each of the sensing means using the transfer function;

means for measuring time of first energy arrival to a sensor of each of the sensing means;

means for calculating a distance from a transducer of the excitation signal applying means to the sensor of each of the sensing means using the measured times of first energy arrival; and

means for calculating dimensions of the touch plate using the calculated transducer-to-sensor distances.